Annals of Arid Zone 37(4): 411-416, 1998

Size and Shape of Plots and Blocks for Field Experiments in Natural Grasslands in Chambal Ravines of South-Eastern Rajasthan

M.C. Agarwal, A.K. Parindyal*, Nirmal Kumar and K.D. Singh*
Central Soil and Water Conservation Research and Training Institute, Dehradun 248 195, India

Abstract: A uniformity trial conducted on natural grasslands of Chambal ravines revealed that the coefficient of variation decreased with the increase in plot size up to 12 m^2. The equation $Y = aX^{-b}$ gave a good fit to the relationship between coefficient of variation (Y) and plot sizes (X). Plot shape had no effect on coefficient of variation, however, plot elongated towards column had shown smaller coefficient of variation. The number of replications indicated that the plot size of 8 to 12 m^2 was suitable. The block efficiency decreased with an increase in block size. The shape of the block had no effect on coefficient of variation. However, the blocks elongated towards rows were found to be more efficient. The relationship ($Y = aX^{-b}$) between coefficient of variation (Y) and block size (X) was also fitted to various plot sizes and shapes.

Key words: Natural grassland, uniformity trial, plot size, plot shape, block size, block shape.

Semi-arid region of south-eastern Rajasthan is characterized by hilly/rocky terrain and almost flat alluvial plains. Out of the total geographical area (4.19 m ha) of the region, 46% of the area is under forest, pasture and grazing lands, culturable waste lands and fallow lands. Ravines are the worst form of land degradation in alluvial plain of the region. Out of 0.452 m ha ravine lands of Rajasthan, nearly 79% (0.356 m ha) is situated along the river Chambal and its tributaries (Prasad and Singh, 1994). Hence, large area of the region is under the grasslands. However, these lands have constantly been overgrazed with the result that no where the vegetation is growing at its optimum stage. Both the primary and the secondary productivity is at a very low level. Thus, immediate improvement and management of these lands is of utmost importance for wasteland development and rural reconstruction with appropriate soil conservation measures.

To achieve these objectives, the field experiments are to be planned in such a way that maximum information is obtained with minimum experimental error. The efficient planning of field experiment, in addition to randomization, replication and local control, also depends upon the suitable plot size, shape and their arrangements in blocks of suitable configuration. Various research workers (Agnihotri and Agarwal, 1982; Handa *et al*., 1987; Ram Babu *et al*., 1980 and 1983) recommended the suitable size

* CS&WCR&TI, Research Center, Kota 324 001, India.

and shape of plots and blocks for conducting field experiments in the grasslands of the different agro-climatic regions of India. At present, this information is lacking for this region and the information generated else where may not be applicable for this region. As such, the field experiments in the region are being laid out using the size and shape of plots and blocks based purely on practical experience and convenience. Thus, a uniformity trial was conducted during 1996 at the Central Soil and Water Conservation Research and Training Institute, Research Centre, Kota.

Materials and Methods

A uniformity trial was conducted on natural grasslands in semi-arid sub-tropical area on 24 x 24 m plots, in the units of 1 x 1 m (rows towards north east - south west and columns towards north west - south east), during 1996. Soils are, in general, clay loam to clay in texture containing 30-48% clay and have brown to dark gray brown colour with pH ranging between 7.2 and 8.5, with the average annual rainfall of 765 mm. The grasses were cut 5 cm above the ground level, during the month of October and the green as well as air dry yields were recorded. However, analysis were carried out on the basis of air dry yield only.

The adjacent 1 m^2 plots were combined to form plots and blocks of different sizes and shapes and the coefficient of variation (CV) for each such arrangement was calculated. The CV values thus obtained were utilized for determining the practicable range of size and shape of plots and blocks. The average CV for different plot sizes, viz., 1 m^2 to 144 m^2 without blocking and with arrangement in blocks of size from 2 to 48 were calculated. The equation $Y = aX^{-b}$ (Smith, 1938) was fitted to the data on average CV (Y) and the plot size (X m^2) separately for each block size and the sum of squares (SS) due to fitted equation was obtained. The number of replications were estimated using the formula:

$$r = V_1/(V_o * X^b)$$

where,

V_1 is the estimated variance between plots of basic unit size, V_o is the variance of

Table 1. Grass yield (q ha^{-1}) in natural grassland of Kota

Grass name	Frequency of species (%)	Air dry yield (q ha^{-1})	Yield composition (%)
Dichanthium annulatum	82.1	25.30	65.3
Heteropogon contortus	39.4	11.77	30.4
Iseilema laxum	12.3	0.41	2.7
Apluda mutica	6.6	1.03	1.0
Eremopogon foveolatus	0.4	0.11	0.3
Atylosia scarabaeoides	6.9	0.08	0.2
Alysicarpus rugosus	0.7	0.03	0.1
Total	148.4*	38.73	100.0

Table 2. Average coefficient of variation (%) with different plot and block sizes in natural grassland of Chambal ravines

Plot size (m^2)	Without arrange-ment in blocks	Block size (plots)							
		2	3	4	6	8	12	16	24
1	23.88	19.93	19.92	20.20	20.40	20.91	20.94	21.34	21.68
2	19.19	14.52	14.71	15.44	15.42	15.99	16.32	14.40	17.01
3	17.39	12.47	12.93	13.34	13.32	14.39	14.36	14.99	15.36
4	16.24	12.11	11.84	12.45	12.89	12.96	13.58	13.69	14.33
6	14.95	10.23	10.12	11.45	11.35	12.23	12.38	12.90	13.23
8	13.73	9.31	9.86	9.82	10.73	10.67	11.50		12.48
9	13.75	8.37		10.01		11.28		11.90	
12	13.02	9.17	9.02	9.91	10.04	10.68	10.99	11.64	
16	12.10	7.75	8.77	8.69	9.74		10.72		
18	12.49	8.65		9.71		10.56		11.31	
24	11.12	7.74	7.94	8.57	8.90	9.54	9.86		
32	11.00	7.56	8.48		9.60				
36	10.84	7.34		8.52		9.43			
48	9.73	6.96	7.09	8.06	8.38				
64	9.81		8.40						
72	9.03	6.72		7.83					
96	8.64	6.69	7.01						
144	8.07	6.40							

treatment mean at a given degree of precision (10% in the present case), X is the plot size under consideration expressed in terms of the number of basic units and 'b' is the adjusted Smith index of soil heterogeneity (Gomez and Gomez, 1983). The total area required for experimentation may be obtained by multiplying the plot size (m^2) with the number of replications for different sizes of the plots and blocks. Further, the relationships between the CV and the block size were also studied.

Results and Discussion

Dichanthium annulatum and *Heteropogon contortus* were dominant grasses in the study area as presence of these species were 82.1% and 39.4% with air dry yield as 65.3% and 30.4%, respectively, of the total grass yield. Other grasses registered their presence as rare one (Table 1).

The average CV decreased from 23.9 to 13.0 without arrangements in blocks and from 19.9 to 9.2, 19.9 to 9.0, 20.2 to 9.9, 20.4 to 10.0, 20.9 to 10.7, 20.9 to 11.0, 21.3 to 11.6 and 21.7 to 11.8 with ar-

Table 3. Smith's equations without and with different block sizes in natural grasslands of Chambal ravines

Number of plots/ block	Equation fitted	Coefficient of determination R^2 (%)
2	$Y = 15.9170X^{-0.2118}$	90.22**
3	$Y = 16.3694X^{-0.2033}$	88.85**
4	$Y = 16.4116X^{-0.1834}$	86.38**
6	$Y = 17.0290X^{-0.1829}$	88.42**
8	$Y = 17.8816X^{-0.1888}$	89.89**
12	$Y = 18.5402X^{-0.1964}$	92.39**
16	$Y = 18.1233X^{-0.1690}$	84.12**
24	$Y = 19.9300X^{-0.2082}$	94.38**
Without arrangement in blocks	$Y = 22.0921X^{-0.2066}$	98.84**

** Significant at 1% level.

rangements in blocks of size 2, 3, 4, 6, 8, 12, 16 and 24 plots, respectively, when the plot size was increased from 1 to 12 m^2. With further increase in the size of plots, the reduction in CV was marginal. The CV increased with an increase in the block size and was highest for without arrangement in blocks, irrespective of the plot size (Table 2).

The value of Smith's coefficient of heterogeneity (b) varied from 0.1690 to 0.2118 for 2 to 24 plots block size and was 0.2066 without arrangement in blocks (Table 3). However, the value of 'b' for blocks of 4 to 8 plots was almost of the same order. Therefore, there appears to be high positive correlation between the neighbouring plots. Hence, the size of the plot is of greater importance in controlling the error variation. The per cent coefficient of determination, (R^2%) varied from 84.12 to 98.84%. Hence, the fitting of equations appeared to be good in all the cases (Table 3).

The shape of the plot had no effect on CV, though plot elongated towards column (longer side towards column) had shown smaller CV in natural grassland of south-eastern Rajasthan.

Number of replications required were highest for the smallest plot size of 1 m^2. It decreased with an increase in the plot size of 8 to 12 m^2; thereafter, there was no appreciable reduction in the number of replications with an increase in plot size (Table 4). In view of these results, as well as practical difficulties in layout of field trials, a plot size of 8 to 12 m^2 appears to be the most suitable. In general, for a given plot size, the average number of replications and experimental area required were higher with larger blocks.

The block efficiencies worked out for all possible 836 combinations of different sizes and shapes gave highest block efficiency of 3.57, and only 8.6% cases of blocks forming were less efficient. The average block efficiency decreased with an increase in block size. Blocks with smaller number of plots may be preferred. Hence, the block size of 6 to 8 plots appears to be most practicable.

As regards the efficiency of blocks of the same size but different shapes, there was no consistent effect of the shape of

Table 4. Minimum number of replications for 10% margin of error of the mean in the natural grassland of Chambal ravines

Plot size (m^2)	Block size								
	Without block	2	3	4	6	8	12	16	24
1	24	17	16	17	17	18	18	19	18
2	19	14	14	14	14	15	15	16	16
3	17	12	12	12	13	13	13	14	14
4	16	11	11	12	12	12	12	13	13
6	14	10	10	10	11	11	11	12	12
8	13	9	9	10	10	10	10		11
9	13	9		9		10		11	
12	12	8	8	9	9	9	9	10	
16	11	8	8	8	8		8		
18	10	7		8		8		9	
24	10	7	7	7	7	8	10		
32	9	6	6		7				
36	8	6		6		7			
48	8	6	6	6	6				
64	7								
72	7	5		5					
96	6	5	5						
144	6	6							

the blocks. However, the blocks elongated towards the rows were found to be more efficient.

To study the relationship between the coefficient of variation and block size, the equation $Y = aX^b$, where Y is the average coefficient of variation and X the number of plots per block, was fitted to block size range 2 to 24 with plots of different sizes and shapes (Table 5). The relationship is seen to describe the underlying relationship satisfactorily for the plot sizes and shapes presented in the Table. The rate of change in coefficient of variation with an increase in the number of plots per block did not vary appreciably with all the plot sizes and shapes.

Acknowledgements

The authors are grateful to the Director, Central Soil and Water Conservation Research and Training Institute, Dehradun, for his encouragement and keen interest, to Mr. B.L. Rathore and Mr. B.K. Upadhyay of Research Center, Kota, for help in the laying out of the plots and collection of

Table 5. Relationship between coefficient of variation (Y) and block size (X) in natural grasslands of Chambal ravine

Plot		Equation fitted	Coefficient of determination
Size (m^2)	Shape (C:R)		R^2 (%)
4	1m x 4m	$Y = 10.0559X^{0.0767}$	85.93**
	2m x 2m	$Y = 10.5653X^{0.0856}$	89.00**
	4m x 1m	$Y = 13.0919X^{0.0592}$	74.95**
6	1m x 6m	$Y = 8.2881X^{0.1080}$	63.89**
	2m x 3m	$Y = 8.9484X^{0.1091}$	82.34**
	3m x 2m	$Y = 8.6881X^{0.1438}$	95.85**
8	1m x 8m	$Y = 5.5117X^{0.2023}$	83.45**
	2m x 4m	$Y = 8.5692X^{0.1094}$	92.44**
	4m x 2m	$Y = 8.5987X^{0.1236}$	89.10**
12	1m x 12m	$Y = 5.1331X^{0.1675}$	86.83**
	2m x 6m	$Y = 8.2652X^{0.1026}$	60.52*
	3m x 4m	$Y = 8.1759X^{0.1361}$	66.95*
	4m x 3m	$Y = 7.4028X^{0.1453}$	77.51**

*, ** Significant at 5% and 1% level, respectively.

data and to Mr. Tamradhwaj for computational assistance. Thanks are also due to Mrs. Nisha Singh for typing the manuscript.

References

Agnihotri, Y. and Agarwal, M.C. 1982. Size and shape of plots and blocks for field experiments in natural grasslands of Siwalik hills. *Indian Journal of Soil Conservation* 10: 73-80.

Gomez, K.A. and Gomez, A.A. 1983. *Statistical Procedures for Agricultural Research*. Second edition, John Wiley & Sons, New York, pp. 478-504.

Handa, D.P., Sreenath, P.R., Rajpati, S.K. and Shikanya, S.R. 1987. Size and shape of plots and blocks for experiments with natural grasses. *Indian Journal of Agricultural Sciences* 57: 606-608.

Prasad, S.N. and Singh, Ratan 1994. Soil erosion and its control in semi-arid region of south-eastern Rajasthan. *Indian Journal of Soil Conservation* 22: 102-111.

Ram Babu, Agarwal, M.C. and Gupta, R.K. 1983. Size and shape of plots and blocks for field experiments in grasslands of outer Himalayas under various slopes. *Indian Journal of Soil Conservation* 11: 39-47.

Ram Babu, Agarwal, M.C., Samraj, P. and Chinnamani, S. 1980. Size and shape of plots and blocks for field trials on natural grasslands in Nilgiri hills. *Indian Journal of Agricultural Sciences* 50: 598-602.

Smith, H.F. 1938. An empirical law describing heterogeneity in the yield of agricultural crops. *Journal of Agricultural Sciences, Cambridge* 28: 1-23.